

PATENT ABSTRACTS OF JAPAN

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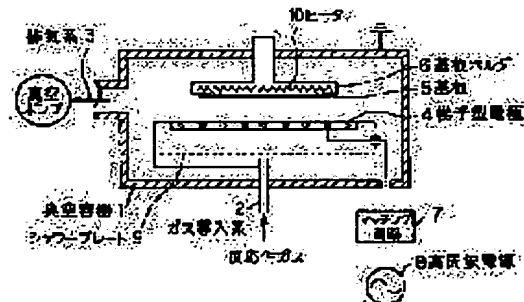
(71)Applicant : MITSUBISHI HEAVY IND LTD

(22)Date of filing : 26.08.1998

(72)Inventor : SATAKE KOJI
SHIGENAKA TOSHIAKI
YAMAKOSHI HIDEO**(54) PLASMA CVD DEVICE AND PRODUCTION OF THIN FILM ELECTRONIC DEVICE****(57)Abstract:**

PROBLEM TO BE SOLVED: To make a plasma generating electrode and an electrode on the side of a substrate electrically independent, to attain the generation of plasma, ion control and the prevention of deterioration in film quality and to obtain uniform plasma of large area by arranging conducting rods feeding high frequency electric power and grounded conducting rods alternately in a laddery state in such a manner that they are insulated with each other.

SOLUTION: In a vacuum vessel 1 a ladder-type electrode 4 and a substrate holder 6 to be mounted with a substrate 5 are placed by being away and opposite to each other, the ladder-type electrode 4 is a plasma generating electrode and is connected to a high frequency power source 8 via a matching circuit 7 for impedance matching. When the conducting rod on the high pressure side of the ladder-type electrode 4 is applied with high frequency electric power, plasma is generated on the space between it and the conducting rod on the grounded side along the electrode side, the electric potential on the substrate side does not directly exert influence and to the ladder-type electrode 4 the substrate 5 and the substrate holder 6 are made electrically independent. In this way, the distribution of the electron density is made continuously uniform, the degree of freedom in the film forming process increases to improve the controllability of the film formation.

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CLAIMS

[Claim(s)]

[Claim 1] The above-mentioned electrode is plasma-CVD equipment characterized by what it is the ladder mold electrode which the conducting bar with which high-frequency power is supplied in the plasma-CVD equipment which has the substrate which countered in the vacuum housing by which the gas feed system and the exhaust-air system were opened for free passage with the electrode connected to the RF electric power supply means and this electrode, and has been arranged, and the conducting bar which were grounded were insulated mutually, and was arranged in the shape of a ladder by turns.

[Claim 2] The distance d between the high-tension-side conducting bars and earth side conducting bars which constitute the above-mentioned electrode is plasma-CVD equipment according to claim 1 which is in abbreviation etc. by making it into twice the amplitude A of the electron in the RF plasma, and is characterized by things.

[Claim 3] The above-mentioned electrode is plasma-CVD equipment according to claim 1 or 2 which considers as a cylindrical ladder mold electrode and is characterized by having the cylindrical substrate holder which had the cylindrical substrate inside this electrode.

[Claim 4] Plasma-CVD equipment according to claim 1, 2, or 3 characterized by connecting the RF generator made frequency adjustable [different from the RF generator connected to the above-mentioned electrode] to the 2nd electrode which supports a substrate.

[Claim 5] Plasma-CVD equipment according to claim 1, 2, 3, or 4 characterized by having the gas pipe which spouts reactant gas between the substrates which stand face to face against the above-mentioned electrode and this electrode so that it may surround around the above-mentioned ladder mold electrode and a substrate.

[Claim 6] The distance of the mutual feeding point seen from the RF generator when it considered as the wavelength λ of the high-frequency power which supplies electric power to the above-mentioned electrode is $\lambda/4$. Plasma-CVD equipment according to claim 1, 2, 3, 4, or 5 characterized by having two or more feeding points which become the following.

[Claim 7] The electrode equipped with two or more feeding points is plasma-CVD equipment according to claim 1, 2, 3, 4, or 5 characterized by having made the electrode which became independent for every feeding point correspond, having formed the unit, and forming a multi-unit.

[Claim 8] The thin film electron device manufacture approach it was made to form membranes by the plasma on the substrate which countered the ladder-like electrode in plasma-CVD equipment according to claim 1, 2, 3, 4, 5, 6, or 7, and has been arranged.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention plasma-izes reactant gas with high-frequency power, relates to the plasma-CVD equipment and the thin film electron device manufacture approach of forming a thin film on a substrate, and relates to the plasma-CVD equipment used for manufacture / development processes, such as a thin film electron device, for example, a thin film transistor, a solar battery, and an electrophotography photo conductor.

[0002]

[Description of the Prior Art] The thin film formation process and ingredient processing process using the plasma are an indispensable technique widely used for a thin film electron device, manufacture of an exotic material, etc. among these, if an example is taken to thin film formation, as plasma-CVD equipment proposed conventionally The zigzag-like plan type coil which bent one wire rod by turns in the shape of U character is formed so that it may be indicated by JP,4-021781,A. There are some which there are some which high-frequency voltage is applied [some] between the substrates which stand face to face against this coil, and generate the plasma, and are going to strengthen field strength, and are going to consider as homogeneity, and are going to obtain a large area thin film.

[0003] It is more specifically in the vacuum housing by which the gas feed system and the exhaust-air system of reactant gas were opened for free passage, and the RF electric field generated between the earth-side electrodes which stood face to face against the electrode for discharge (high-tension side) and this which are an above-mentioned zigzag-like plan type coil, and carried the substrate generate the plasma, this generated plasma decomposes reactant gas, a reaction kind is made, and a thin film deposits on a substrate.

[0004] Moreover, as another conventional plasma-CVD equipment, high-frequency voltage is applied between the ladder-like flat-surface coils and substrates which consist of two or more wire rods, the plasma tends to be generated, and field strength tends to be strengthened, and it is going to consider as homogeneity, and is going to obtain a large area thin film so that it may be indicated by JP,4-236781,A.

[0005] It is the same as the above-mentioned conventional example to generate the plasma by RF electric field also about this ladder-like flat-surface coil, and to deposit a thin film on a substrate.

[0006]

[Problem(s) to be Solved by the Invention] However, what applies high-frequency voltage to the high-tension-side electrode which are the shape of zigzag and a ladder-like flat-surface coil as mentioned also to the above-mentioned conventional example, and the earth side electrode which carried the substrate is common. If it puts in another way, it will be common that the high-tension-side electrode and the earth side electrode have joined together electrically, the physical properties of the substrate carried on the earth side electrode will affect RF electric field, plasma production will be affected, and plasma production control may become difficult.

[0007] Moreover, in order to improve a membrane formation rate, when high-frequency power is increased, a substrate front face will be direct made into the strong plasma, a substrate front face receives the damage by the ion in the plasma, and the problem that membraneous quality deteriorates also has it.

[0008] Furthermore, since high-frequency voltage will be applied between these high-tension-sides electrode and a substrate, deviation occurs in this point electron density distribution and it does not become continuous distribution, homogeneity membrane formation cannot be performed easily, and although a large area thin film is obtained with the flat-surface coil of the shape of the shape of zigzag, or a ladder, even if it, as a result, forms

a large area thin film, it has a limitation.

[0009] This invention aims at offer of the plasma-CVD equipment and the thin film electron device manufacture approach of having been made in view of the above-mentioned problem, and preventing degradation of the difficulty of plasma control, or the membraneous quality on the front face of a substrate as what became independent electrically about the plasma production electrode and the electrode by the side of a substrate, and having been made to advance further large area-ization.

[0010]

[Means for Solving the Problem] This invention which attains the above-mentioned purpose has the following invention specification matter. In the plasma-CVD equipment which has the substrate which the 1st invention countered in the vacuum housing by which the gas feed system and the exhaust-air system were opened for free passage with the electrode connected to the RF electric power supply means, and this electrode, and has been arranged, the above-mentioned electrode is characterized by to be the ladder mold electrode which the conducting bar with which high-frequency power is supplied, and the grounded conducting bar were insulated mutually, and was arranged in the shape of a ladder by turns.

[0011] The 1st invention has the 2nd invention, and the distance d between the high-tension-side conducting bars and earth side conducting bars which constitute the above-mentioned electrode is in abbreviation etc. by making it into twice the amplitude A of the electron in the RF plasma, and is characterized by things.

[0012] The 1st or 2nd invention has the 3rd invention, the above-mentioned electrode is used as a cylindrical ladder mold electrode, and it is characterized by having the cylindrical substrate holder which had the cylindrical substrate inside this electrode.

[0013] 4th invention is characterized by being in the 1st, 2nd, or 3rd invention, and connecting the RF generator made frequency adjustable [different from the RF generator connected to the above-mentioned electrode] to the 2nd electrode which supports a substrate.

[0014] 5th invention is characterized by being in the 1st, 2nd, 3rd, or 4th invention, and having the gas pipe which spouts reactant gas between the substrates which stand face to face against the above-mentioned electrode and this electrode so that it may surround around the above-mentioned ladder mold electrode and a substrate.

[0015] For the 6th invention, the distance of the mutual feeding point seen from the RF generator when it considered as the wavelength λ of the high-frequency power which is in the 1st, 2nd, 3rd, 4th, or 5th invention, and supplies electric power to the above-mentioned electrode is $\lambda/4$. It is characterized by having two or more feeding points which become the following.

[0016] It is characterized by for the 1st, 2nd, 3rd, 4th, or 5th invention having the 7th invention, having made the electrode equipped with two or more feeding points equivalent to the electrode which became independent for every feeding point, having formed the unit, and forming a multi-unit.

[0017] 8th invention is characterized by the thin film electron device manufacture approach it was made to form membranes by the plasma on the substrate which countered the ladder-like electrode of the plasma-CVD equipment of the 1st, 2, 3, 4, 5 and 6, or 7, and has been arranged.

[0018]

[Embodiment of the Invention] Here, an example of the gestalt of operation of this invention is explained with reference to drawing 1 - drawing 10. Drawing 1 is the cross-section block diagram of the RF plasma CVD system of this invention. In drawing 1, a vacuum housing 1 has a gas entrance with the exhaust air system 3 connected to the gas feed system 2 connected to sources of gas (illustration abbreviation), such as a chemical cylinder, and the vacuum pump. It estranges, into this vacuum housing 1, the ladder mold electrode 4 and the substrate holder 6 which carries a substrate 5 confront each other, and is placed, and the ladder mold electrode 4 is a plasma production electrode, and is connected to RF generator 8 through the matching circuit 7 for impedance matching.

[0019] Here, two or more conducting bars 4S and 4G by which the diameter was carried out estrange the structure of the ladder mold electrode 4 mutually, and it is arranged in between metal frame 4a of the high-tension side for supplying electric power in high-frequency power, as shown also in drawing 2, and metal frame 4b of the earth side. By metal frame 4b of the earth side, through insulator strike 4c, it insulates electrically and thing 4S which it is inserted in metal frame 4a of the high-tension side among this conducting bar, and are connected electrically are inserted. Moreover, by metal frame 4a of the high-tension side, through

insulator strike 4c, thing 4G which it is inserted in metal frame 4b of the earth side among conducting bars, and are connected electrically insulate electrically, and are connected. Therefore, high-frequency voltage will join metal frame 4a of the high-tension side, and conducting bar 4S, and, on the other hand, conducting bar 4G and metal rod 4b will be grounded. Drawing 1 shows high-tension-side conducting bar 4S and a white round head for a black dot as conducting bar 4G of the earth side.

[0020] Moreover, the shower plate 9 which has a gas feed system 2 and a centrum open for free passage is arranged to the substrate holder 6 in the opposite side centering on the ladder mold electrode 4, and gas spouts from many jet holes of the shower plate 9 to homogeneity. On the other hand, in the substrate holder 9, the heater 10 for heating a substrate 5 is arranged. In addition, the substrate holder 6 as a result the substrate 5, and the vacuum housing 1 are grounded.

[0021] In here, when high-frequency power is applied to conducting bar 4S of the high-tension side of the ladder mold electrode 4, along with an electrode surface, the plasma generates among conducting bar 4G of the earth side. And this plasma will be generated along with conducting bars 4S and 4G, and the potential by the side of a substrate does not do direct effect in generation of this plasma. That is, a substrate 5 and the substrate holder 6 become what became independent electrically to the ladder mold electrode 4.

[0022] Moreover, the amplitude A of the electron in the RF plasma is expressed with a degree type [a-one number].

[Equation 1]

$$A = \frac{E}{\omega \sqrt{(1/\mu)^2 + (m_e/e)\omega^2}}$$

Setting here, E is field strength and mu is electronic mobility and me. Amount of electronic charge and omega=2pif is mass of electrons, and e is the angular frequency of high-frequency power. And distance d of conducting bar 4S of the high-tension side arranged by turns and conducting bar 4G which were grounded is carried out near 2 double [of the amplitude A of said electron]. That is, it is referred to as d**2A. Temporarily, if it is d<<2A, the electron in the plasma will reach a conducting bar easily, and the plasma will not be generated well as a result. It is because the plasma with the large volume will be generated between conducting bars and the homogeneity of the plasma is worsened as a result on the other hand, although the plasma is generated in d>>2A. Moreover, the distance with the structure of the electrode circumference also needs to make it larger than d at least, in order to avoid discharge between an electrode and the structure. Support of an electrode is performed by insulators, such as a ceramic, at this time.

[0023] Between conducting bar 4S and 4G is arranged to describe an example using drawing 2 mentioned above so that it may be set to d=2A. The plasma will be efficiently formed of the RF electric field formed between conducting bar 4S and 4G with this configuration. Therefore, by arranging conducting bar 4G of the conducting bar 4S and the earth side of the high-tension side in in the shape of a ladder by turns, it is uniform as the whole electrode and the large area plasma can be generated.

[0024] 60MHz As a result of carrying out numerical simulation of 2-dimensional one supposing the case where electric power is supplied to this ladder mold electrode 4 in high-frequency power, the spatial distribution of the electron density in the plasma became like drawing 3 . As shown in drawing 3 , the electric consistency is continuously distributed along with the list of the conducting bar of a ladder mold electrode, and it is shown that uniform plasma production is possible at a large area. That is, the reactant gas supplied in the vacuum housing is decomposed by the plasma generated along with the electrode surface, and a reaction kind is generated. This reaction kind serves as uniform distribution in the neighborhood which was spread promptly and reached workpiece under the number mTorr which is the gas pressure usually used in this kind of process - hundreds mTorr(s). For this reason, uniform processing by this reaction kind is attained.

[0025] Drawing 4 shows the modification of drawing 1 and shows the example which formed the cylindrical ladder mold electrode 41 to the cylindrical substrate 51. For example, it is premised on CVD to the substrate of the shape of a cylinder which is represented by the photo conductor drum as an example. In the vacuum housing 1, the cylindrical substrate holder 61 and this alignment holding the cylindrical substrate 51 install the cylindrical ladder mold electrode 41. In this case, like drawing 4 , the list of the conducting bar which forms the stair of the cylindrical ladder mold electrode 41 may be arranged in a circumferencial direction, or may be

arranged in cylinder shaft orientations.

[0026] RF generator 8 is connected to the cylindrical ladder mold electrode 41 through the matching circuit 7 like the configuration of drawing 1, and it is still the same as that of the case of drawing 1 that the plasma is generable along with this conducting bar of the cylindrical ladder mold electrode 41 with arrangement by turns [of a high-tension-side conducting bar and an earth side conducting bar]. Furthermore, it is made to have spouted reactant gas from the shower plate 9 behind the cylindrical ladder mold electrode 41 like drawing 1, and the uniform membrane formation to the front face of a cylindrical substrate is attained with the reaction kind disassembled by the plasma. That is, with the configuration of drawing 4, it has composition which formed the thing of drawing 1 in the shape of a cylinder.

[0027] Drawing 5 shows the example of further others. Drawing 5 equips with the 2nd electrode 11 the stage on which a substrate 5 is put, and adds the configuration which connects another RF generator 13 to this 2nd electrode 11 through the matching circuit 12 to the configuration of drawing 1. Since according to this drawing 5 it will change in time on that frequency, a vacuum housing 1 and the substrate holder 6 will moreover be grounded and the surface potential of the substrate 5 carried on the 2nd electrode 11 will be relatively superimposed on a negative electrical potential difference by high-frequency power. It is accelerated according to the potential difference changed in time between the space potential in the plasma, and the surface potential of a substrate 5, and incidence of the ion in the plasma generated with the ladder mold electrode 4 is carried out to the substrate front face under membrane formation.

[0028] Drawing 6 is SiH₃ which carries out incidence to the substrate 5 when changing the frequency of the high-frequency power which supplies electric power to the 2nd electrode 11. Ion (drawing solid line) and H⁺ Change of distribution of each ion energy of ion (drawing middle point line) is shown. As shown in drawing 6, although energy distribution becomes large, if a frequency is made high (for example, 70MHz), since breadth will become small, on a low frequency (for example, 13.56 MHz), incidence ion energy is understood that it is controllable with the magnitude of a frequency. Since the ion with about dozens of eV incidence energy promoting the annealing effectiveness under membrane formation, and making membraneous quality precise and good is also known while too high ion energy increases the defect density in the film and membraneous quality is degraded, control of the ion energy using the high-frequency power depended on this example is very effective.

[0029] Drawing 7 is other examples, in this drawing 7, arranges the gas pipe 14 of the shape of a ring of the magnitude which surrounds this electrode 4 and substrate 5 between the ladder mold electrode 4 and a substrate 5, and has the configuration to which the configuration of many gas ports is carried out inside the gas pipe 14 of the shape of this ring. The reactant gas which becomes the basis of a membrane-formation precursor is flowed out of the gas pipe 14 of the shape of this ring, and it is made to form membranes from a gas feed system 2 with the reaction kind decomposed and made by the plasma which introduced gas other than the reactant gas which becomes the basis of a membrane formation precursor, and that gas generated between the conducting bars of the ladder mold electrode 4 by decomposing the reactant gas introduced from the gas pipe 14. That is, the presentation of the reaction kind used as a membrane formation precursor can be controlled by decomposing the reactant gas from a gas pipe 14 by the reaction species by decomposition of another gas, without decomposing reactant gas with the direct plasma, as shown in drawing 1, drawing 4, and drawing 5.

[0030] Ar gas from the concrete for example, shower plate 9 ladder mold electrode 4 in back -- introducing -- SiH₄ from a gas pipe 14 Ar metastable atom generated by the electronic collision in the plasma when introducing gas, and SiH₄ the reaction of gas -- SiH₂ The reaction kind SiH₃ which serves as a membrane formation precursor since it generates, and SiH₂ etc. -- setting -- SiH₂ A ratio can be gathered. Moreover, for example, from the shower plate 9, it is H₂. Gas is introduced and it is SiH₄ similarly from a gas pipe 14. H atom and SiH₄ which were generated by the electronic collision in the plasma when introducing gas It is SiH₃ by the reaction. The reaction kind SiH₃ which serves as a membrane formation precursor since it generates, and SiH₂ It sets and is SiH₃. A ratio can be gathered. Anyway, SiH₄ It can be made a different presentation from the presentation of the reaction kind which decomposed and generates gas by the direct plasma, and becomes controllable [a membrane formation reaction].

[0031] Although the example was given in drawing 1, drawing 4, drawing 5, and drawing 7 above, mutual application is possible for these examples, they can combine the configuration of drawing 5 and drawing 7 with the cylinder structure of drawing 4, and can also combine the configuration of drawing 5 and drawing 7.

[0032] As explained, in this way, with the plasma-CVD equipment in this example By having arranged the conducting bar with which electric power is supplied to high-frequency power, and the grounded conducting bar in the shape of a ladder by turns At least, it becomes what became independent electrically, electron density distribution turns into uniform distribution continuously, the degree of freedom of a membrane formation process increases, the controllability for high quality membrane formation improves, and it is expected by the substrate side that much more large area thin film is a ladder-like electrode.

[0033] In old explanation, although lessons was taken from the plasma production equalized by the large area and being stated, reference is made also about high-frequency power here. Generation of the high frequency plasma is 13.56 MHz which decreasing the ion damage to a substrate etc. was performed for high quality processing, and has been used conventionally. They are still higher dozens - 100MHz of numbers outside. High-frequency power is being used. However, if wavelength becomes comparable as electrode size with high-frequency-izing of high-frequency power, a standing wave will occur, the electron capture effectiveness by the RF becomes strong, the plasma becomes [plasma distribution becomes an ununiformity, or] is easy to be generated between an electrode and the surrounding structure locally, and uniform generation is becoming difficult by the large area of the plasma.

[0034] Then, the problem that plasma distribution becomes an ununiformity is solved, using conversely the property which the plasma localizes according to the above-mentioned electron capture effectiveness as the further amelioration. As mentioned above, with an example of the gestalt of operation of this invention Although a large area and the uniform plasma are generated as the whole electrode and it is made to realize uniform processing by installing the ladder mold electrode 4 which consists of two or more conducting bars which arranged in by turns conducting bar 4S by which electric power was supplied to high-frequency power, and conducting bar 4G which were grounded in the shape of a ladder in a vacuum housing 1 In being sufficiently large as compared with the dimension of the ladder mold electrode 4, about the electric supply to this electrode, a problem does not have the wavelength λ by the frequency of high-frequency power at installation of the feeding point in one point to high-tension-side metal rod 4a. However, it is $\lambda/4$ by the wavelength λ based on the frequency of high-frequency power. When die length becomes comparable as the length of an electrode, or a horizontal dimension, in order to invite the ununiformity of the plasma according to generating of a standing wave, a mutual distance is $\lambda/4$, in view of an RF generator side. It is possible to prepare two or more feeding points which become the following.

[0035] When wavelength of the high-frequency power which supplies electric power to the above-mentioned ladder mold electrode 4 is set to λ using drawing 8 , the length of an electrode or a horizontal dimension is $\lambda/4$. When becoming comparable, an example is explained about the configuration of the electrode for making distribution of voltage uniform with the whole electrode. In the example shown in this drawing 8 , high-tension-side metal frame 4a and earth side metal frame 4b were prepared the pair every, and it has both sides with the earth side metal frame four b1 and four b2, and has the high-tension-side metal frame four a1 and four a2 in the center, respectively. And it is each feeding points [which the two feeding points 16a, 16b, 16c, and 16d were installed in the high-tension-side metal frame four a1 and four a2, respectively, and were seen from the power source / 16a, 16b, 16c, and 16d] distance $\lambda/4$ It is considering as the following.

[0036] Drawing 9 shows the relation between the frequency of high-frequency power, and the distribution of voltage generated during the feeding point. 100MHz a case -- $\lambda =$ -- since it is 2m -- the distance L during the feeding point, and $L = \lambda/2$ It becomes relation and very big distribution of voltage occurs at this time. $L < \lambda/4$ Becoming 54.24 MHz Below, distribution of voltage is a mutual distance at the time of [remarkable] extent entropy being carried out and preparing two or more feeding points $\lambda/4$ It is the basis made into the following. As mentioned above, since uniform plasma production became possible between each conducting bar like the case of drawing 2 and the frequency of high-frequency power became high when having arranged two or more feeding points and generating distribution of voltage in about 1 appearance along with the conducting bar with the whole electrode, wavelength λ becomes small, and it is $\lambda/4$. Even when almost comparable as an electrode dimension, it becomes generable [the uniform plasma] by the large area.

[0037] When the frequency of the high-frequency power which supplies electric power to the above-mentioned ladder mold electrode 4 becomes high and makes it wavelength λ , it is $\lambda/2$. When becoming larger than the length of an electrode, or a horizontal dimension, the number of the feeding points must also be

increased. At this time, it has connected electrically, and it sees from a power source, and is $\lambda/4$. When the feeding point in the location which more than left exists, the standing wave generated by these feeding points interferes mutually, and there is a possibility of worsening distribution of voltage as a result. This is controlled and the configuration of the electrode for making distribution of voltage uniform with the whole electrode is explained using drawing 10. Drawing 10 is that to which only the required electrode surface product has arranged two or more units for the electrode which was used in drawing 8, and by which two or more electric supply was carried out in a flat surface as one electrode unit 17, and drawing is an example which has arranged four units. It does not connect [that electric power is only respectively supplied to high-frequency power, and] with each unit electrically between units. By carrying out like this, it is $\lambda/4$. Interference of the standing wave of the feeding points left above is lost, and becomes generable [the plasma uniform as a whole at a large area] by arranging the unit in which the plasma was respectively generated by homogeneity in a flat surface.

[0038]

[Effect of the Invention] According to this invention, the following effectiveness is done so as explained above. In the plasma-CVD equipment which has the substrate which countered with the electrode connected to the RF electric power supply means, and this electrode, and has been arranged in the 1st invention in the vacuum housing by which the gas feed system and the exhaust air system were opened for free passage The above-mentioned electrode by having considered as the ladder mold electrode which the conducting bar with which high-frequency power is supplied, and the grounded conducting bar were insulated mutually, and was arranged in the shape of a ladder by turns It will become independent of a substrate side electrically, plasma production control, ion control, and equalization are attained, and membrane formation control, degradation prevention of membranous quality, and further large area-ization can be attained.

[0039] The distance d between the high-tension-side conducting bars and earth side conducting bars with which the 2nd invention constitutes the above-mentioned electrode in addition to the 1st invention equalizes the plasma to generate by abbreviation etc. having been by making it into twice the amplitude A of the electron in the RF plasma, and having considered as things.

[0040] In the 3rd invention, the substrate of a cylindrical shape can be coped with by in addition to the 1st or 2nd invention, having used the above-mentioned electrode as the cylindrical ladder mold electrode, and having had the cylindrical substrate holder equipped with the cylindrical substrate inside this electrode.

[0041] By being in the 1st, 2nd, or 3rd invention, and connecting an RF generator other than the RF generator connected to the above-mentioned electrode to the 2nd electrode which supports a substrate, the 4th invention can control incidence ion energy by changing the wavelength of a frequency with the 2nd electrode, and can obtain good membranous quality.

[0042] By being in the 1st, 2nd, 3rd, or 4th invention, and having had tubing which spouts reactant gas between the substrates which stand face to face against the above-mentioned electrode and this electrode so that it might surround around the above-mentioned ladder mold electrode and a substrate, the 5th invention is not decomposing the reactant gas from a gas pipe directly with the plasma, but decomposing another gas, and the presentation control of a reaction kind of it is attained.

[0043] the 6th invention -- the [1st and 2nd] -- the distance of the mutual feeding point seen from the RF generator when it considered as the wavelength λ of the high-frequency power which is in 3 4th or 5th invention, and supplies electric power to the above-mentioned electrode -- $\lambda/4$ By having had two or more feeding points which become the following, the plasma ununiformity by standing wave generating can be prevented.

[0044] The 1st, 2nd, 3rd, 4th, or 5th invention has the 7th invention, and the electrode equipped with two or more feeding points can be made into uniform plasma production by the large area by having made the electrode which became independent for every feeding point correspond, having formed the unit, and having formed the multi-unit.

[0045] Each above-mentioned invention has the 8th invention, and it manufactures the electron device which formed membranes with the plasma on the substrate.

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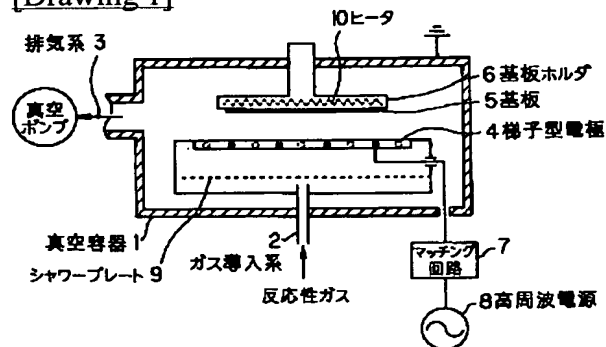
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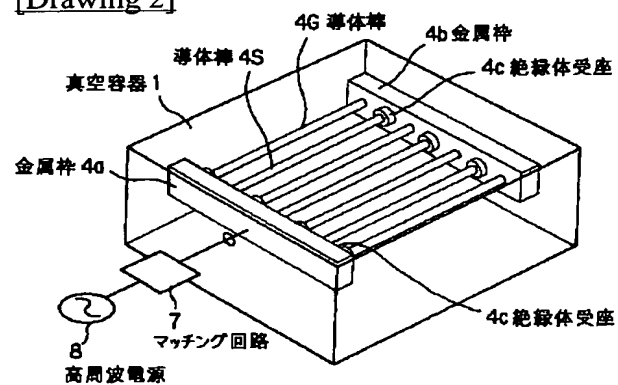
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DRAWINGS

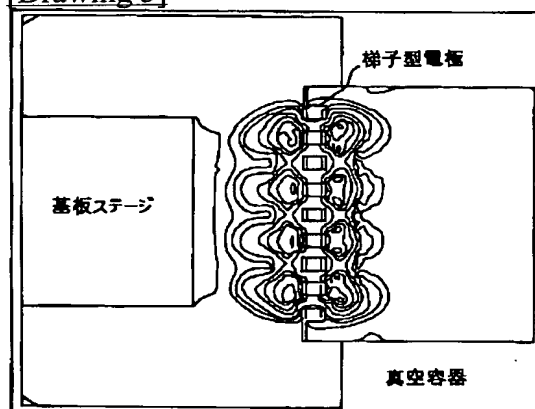
[Drawing 1]



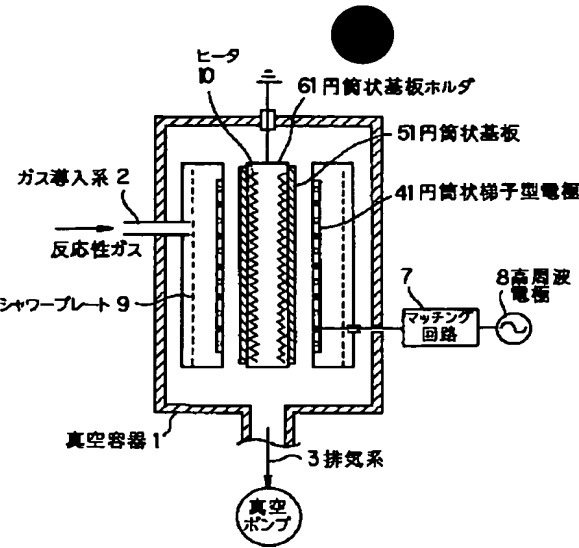
[Drawing 2]



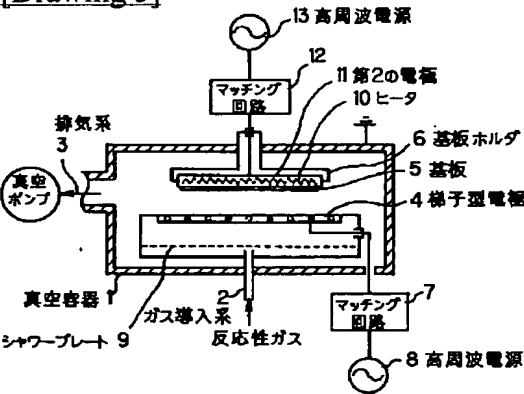
[Drawing 3]



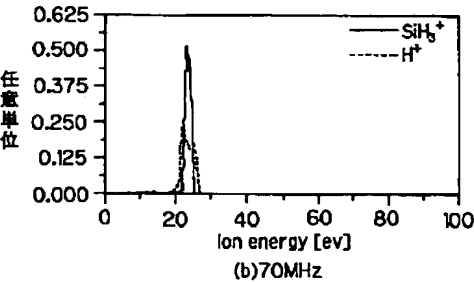
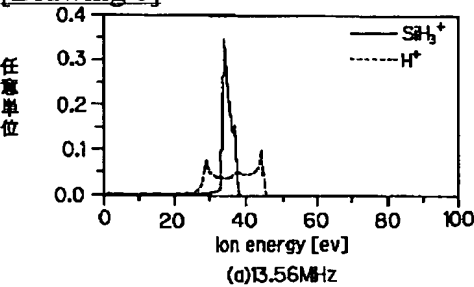
[Drawing 4]



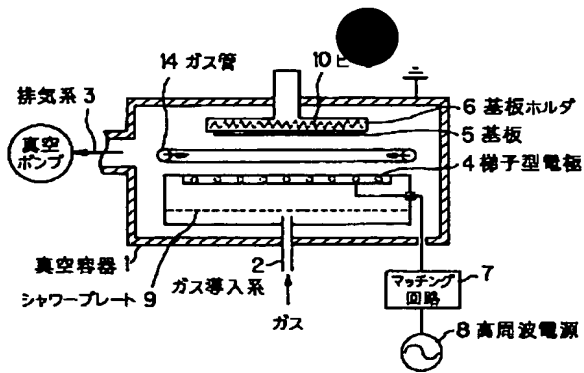
[Drawing 5]



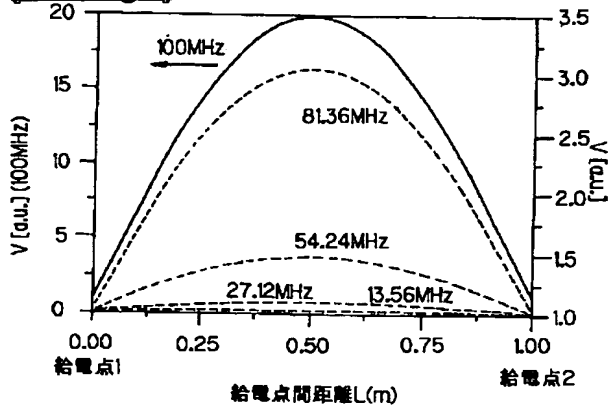
[Drawing 6]



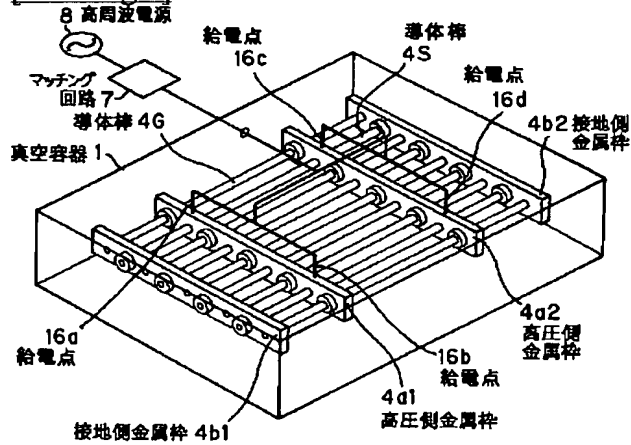
[Drawing 7]



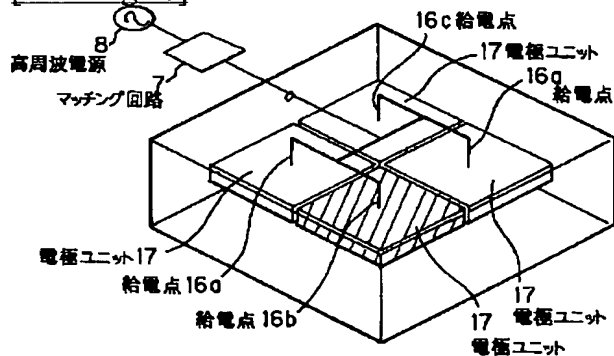
[Drawing 9]



[Drawing 8]



[Drawing 10]



[Translation done.]

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(71) 出願人 000006208

三菱重工業株式会社

東京都千代田区丸の内二丁目 5 番 1 号

(72) 発明者 佐竹 宏次

神奈川県横浜市金沢区幸浦一丁目 8 番地 1

三菱重工業株式会社基盤技術研究所内

(72) 発明者 茂中 俊明

神奈川県横浜市金沢区幸浦一丁目 8 番地 1

三菱重工業株式会社基盤技術研究所内

(74) 代理人 100078499

弁理士 光石 俊郎 (外 2 名)

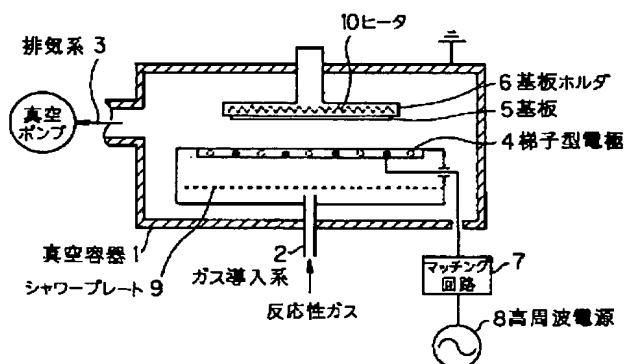
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(54) 【発明の名称】 プラズマ C V D 装置及び薄膜電子デバイス製造方法

(57) 【要約】

【課題】 プラズマ制御が可能で膜質劣化もなく大面積化を図るようにしたプラズマ C V D 装置及び薄膜電子デバイス製造方法を提供する。

【解決手段】 真空容器 1 内のプラズマ生成電極を、高周波電力が供給される導体棒 4 S と接地された導体棒 4 G とが相互に絶縁されて交互に梯子状に配列された梯子型電極としたものである。



【特許請求の範囲】

【請求項 1】 ガス導入系と排気系とが連通された真空容器内に、高周波電力供給手段に接続された電極とこの電極と対向して配置された基板とを有するプラズマ CVD 装置において、

上記電極は、高周波電力が供給される導体棒と接地された導体棒とが相互に絶縁されて交互に梯子状に配列された梯子型電極である、

ことを特徴とするプラズマ CVD 装置。

【請求項 2】 上記電極を構成する高圧側導体棒と接地側導体棒との間の距離 d は、高周波プラズマ中の電子の振幅 A の 2 倍に略等しいことを特徴とする請求項 1 記載のプラズマ CVD 装置。

【請求項 3】 上記電極は、円筒状梯子型電極とし、この電極の内側に円筒状基板を備えた円筒状基板ホルダを備えたことを特徴とする請求項 1 又は 2 記載のプラズマ CVD 装置。

【請求項 4】 上記電極に接続される高周波電源とは別の周波数可変とした高周波電源を基板を支持する第 2 の電極に接続することを特徴とする請求項 1、2 又は 3 記載のプラズマ CVD 装置。

【請求項 5】 上記電極とこの電極と対峙する基板との間に反応性ガスを噴出するガス管を、上記梯子型電極及び基板のまわりに囲むように備えたことを特徴とする請求項 1、2、3 又は 4 記載のプラズマ CVD 装置。

【請求項 6】 上記電極に給電する高周波電力の波長 λ としたとき、高周波電源からみた互いの給電点の距離が $\lambda/4$ 以下となる複数の給電点を備えたことを特徴とする請求項 1、2、3、4 又は 5 記載のプラズマ CVD 装置。

【請求項 7】 複数の給電点を備えた電極は、各給電点ごとに独立した電極に対応させてユニットを形成し、複数ユニットを形成したことを特徴とする請求項 1、2、3、4 又は 5 記載のプラズマ CVD 装置。

【請求項 8】 請求項 1、2、3、4、5、6 又は 7 記載のプラズマ CVD 装置における梯子状電極に対向して配置された基板上にプラズマにより成膜するようにした薄膜電子デバイス製造方法。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は、高周波電力により反応性ガスをプラズマ化し、基板上に薄膜を形成するプラズマ CVD 装置及び薄膜電子デバイス製造方法に係るものであり、薄膜電子デバイス、例えば薄膜トランジスタ、太陽電池、電子写真感光体等の製造・開発プロセスに用いられるプラズマ CVD 装置に関する。

【0002】

【従来の技術】プラズマを用いた薄膜形成プロセスや材料加工プロセスは、薄膜電子デバイスや新材料の製造等に広く用いられている必要不可欠な技術である。このう

ち、薄膜形成に例をとると、従来より提案されているプラズマ CVD 装置としては、特開平 4-021781 号公報に開示される如く、例えば 1 本の線材を U 字状に交互に折り曲げたジグザグ状平面形コイルを形成し、このコイルと対峙する基板との間に高周波電圧をかけてプラズマを発生させるものがあり、電界強度を強くしかつ均一として大面積薄膜を得ようとするものがある。

【0003】より具体的には、反応性ガスのガス導入系と排気系とが連通された真空容器内にあって、上述のジグザグ状平面形コイルである放電用（高圧側）電極とこれに対峙して基板を載せた接地側電極との間に発生する高周波電界によりプラズマを生成し、この生成したプラズマにより反応性ガスを分解して反応種を作り、基板上に薄膜を堆積するというものである。

【0004】また、別の従来のプラズマ CVD 装置としては、特開平 4-236781 号公報に開示される如く、例えば複数本の線材からなる梯子状平面コイルと基板との間に高周波電圧をかけてプラズマを発生させ、電界強度を強くしかつ均一として大面積薄膜を得ようとするものである。

【0005】この梯子状平面コイルについても高周波電界によりプラズマを生成し、基板上に薄膜を堆積することは前述の従来例と同じである。

【0006】

【発明が解決しようとする課題】しかしながら、上述の従来例にも挙げるごとくジグザグ状や梯子状平面コイルである高圧側電極と基板を載せた接地側電極とに高周波電圧を加えるものが一般的であり、換言すれば高圧側電極と接地側電極とが電氣的に結合しているのが一般的であり、接地側電極上に載せた基板の物性が高周波電界に影響を及ぼしプラズマ生成に影響を与えることになって、プラズマ生成制御が困難になることがある。

【0007】また、成膜速度を向上するために高周波電力を増加した場合、基板表面が強いプラズマに直接さらされることとなり、基板表面がプラズマ中のイオンによるダメージを受け、膜質が劣化するという問題もある。

【0008】更には、ジグザグ状や梯子状の平面コイルにより大面積薄膜を得るといっても、これら高圧側電極と基板との間に高周波電圧をかけることになり、かかる点電子密度分布に片寄りが発生し連続分布とならないため均一成膜はできにくく、この結果大面積薄膜を形成するにしても限界がある。

【0009】本発明は、上述の問題に鑑みなされたもので、プラズマ生成電極と基板側の電極とを電氣的に独立したものとして、プラズマ制御の困難性や基板表面の膜質の劣化を防止し、また更なる大面積化を進めるようにしたプラズマ CVD 装置及び薄膜電子デバイス製造方法の提供を目的とする。

【0010】

【課題を解決するための手段】上述の目的を達成する本

発明は、次の発明特定事項を有する。第1の発明は、ガス導入系と排気系とが連通された真空容器内に、高周波電力供給手段に接続された電極とこの電極と対向して配置された基板とを有するプラズマCVD装置において、上記電極は、高周波電力が供給される導体棒と接地された導体棒とが相互に絶縁されて交互に梯子状に配列された梯子型電極であることを特徴とする。

【0011】第2の発明は、第1の発明にあって、上記電極を構成する高圧側導体棒と接地側導体棒との間の距離dは、高周波プラズマ中の電子の振幅Aの2倍に略等しいことを特徴とする。

【0012】第3の発明は、第1又は第2の発明にあって、上記電極は、円筒状梯子型電極とし、この電極の内側に円筒状基板を備えた円筒状基板ホルダを備えたことを特徴とする。

【0013】第4の発明は、第1、第2又は第3の発明にあって、上記電極に接続される高周波電源とは別の周波数可変とした高周波電源を基板を支持する第2の電極に接続することを特徴とする。

【0014】第5の発明は、第1、第2、第3又は第4の発明にあって、上記電極とこの電極と対峙する基板との間に反応性ガスを噴出するガス管を、上記梯子型電極及び基板のまわりに囲むように備えたことを特徴とする。

【0015】第6の発明は、第1、第2、第3、第4又は第5の発明にあって、上記電極に給電する高周波電力の波長λとしたとき、高周波電源からみた互いの給電点の距離がλ/4以下となる複数の給電点を備えたことを特徴とする。

【0016】第7の発明は、第1、第2、第3、第4、又は第5の発明にあって、複数の給電点を備えた電極は、各給電点ごとに独立した電極に対応させてユニットを形成し、複数ユニットを形成したことを特徴とする。

【0017】第8の発明は、第1、2、3、4、5、6又は7のプラズマCVD装置の梯子状電極に対向して配置された基板上にプラズマにより成膜するようにした薄膜電子デバイス製造方法の特徴とする。

【0018】

【発明の実施の形態】ここで、図1～図10を参照して本発明の実施の形態の一例を説明する。図1は本発明の高周波プラズマCVD装置の断面構成図である。図1において、真空容器1は、ガスボンベ等のガス源（図示省略）に接続されたガス導入系2と真空ポンプに接続された排気系3との気体出入口を有する。この真空容器1内には、梯子型電極4と基板5を載せる基板ホルダ6とが離間して対峙して置かれ、梯子型電極4はプラズマ生成電極であり、インピーダンスマッチングのためのマッチング回路7を介して高周波電源8に接続される。

【0019】ここで、梯子型電極4の構造は、図2にも示すように高周波電力を給電するための高圧側の金属棒

4aと接地側の金属棒4bとの間に差し渡された複数本の導体棒4S、4Gが互いに離間して並べられる。この導体棒のうち高圧側の金属棒4aに差し込まれ電氣的に接続するもの4Sは、接地側の金属棒4bでは絶縁体受座4cを介して電氣的に絶縁されて差し込まれる。また、導体棒のうち接地側の金属棒4bに差し込まれて電氣的に接続するもの4Gは、高圧側の金属棒4aでは絶縁体受座4cを介して電氣的に絶縁して接続される。したがって、高圧側の金属棒4aと導体棒4Sには高周波電圧が加わり、反面、導体棒4G及び金属棒4bは接地されることになる。図1では黒丸を例えば高圧側導体棒4S、白丸を接地側の導体棒4Gとして示す。

【0020】また、梯子型電極4を中心として基板ホルダ6に対して反対側には、ガス導入系2と連通する中空部を有するシャワープレート9が配置されており、シャワープレート9の多数の噴出孔からは均一にガスが噴出するようになっている。一方、基板ホルダ9内には基板5を加熱するためのヒータ10が配置されている。なお、基板ホルダ6ひいては基板5及び真空容器1は接地されている。

【0021】ここにおいて、梯子型電極4の高圧側の導体棒4Sに高周波電力を加えた場合、接地側の導体棒4Gとの間にて電極面に沿ってプラズマが生成する。そして、このプラズマは導体棒4S、4Gに沿って生成することになり、このプラズマの生成に当たって基板側の電位は直接影響を及ぼさない。つまり、梯子型電極4に対して基板5及び基板ホルダ6は電氣的に独立したものとなる。

【0022】また、高周波プラズマ中の電子の振幅Aは、次式〔数1〕にて表される。

【数1】

$$A = \frac{E}{\omega \sqrt{(1/\mu)^2 + (m_e/e)\omega^2}}$$

ここにおいて、Eは電界強度、μは電子の移動度、m_eは電子の質量、eは電子の電荷量、ω = 2πfは高周波電力の角周波数である。そして、交互に配置された高圧側の導体棒4Sと接地された導体棒4Gとの距離dを前記電子の振幅Aの2倍近傍とする。つまりd ≒ 2Aとする。仮に、d ≪ 2Aであれば、プラズマ中の電子が容易に導体棒に到達して結果的にプラズマはうまく生成されなくなる。一方、d ≫ 2Aでは、プラズマが生成されるが、導体棒間に体積の大きいプラズマが生成されることになり、結果的にプラズマの均一性を悪化させるからである。また、電極周辺の構造物との距離は、電極と構造物との間での放電を避けるために、少なくともdより大きくすることも必要である。この時、電極の支持はセラミック等の絶縁体で行われる。

【0023】前述した図2を用いて一例を述べるに、導

体棒 4 S, 4 G 間を $d = 2 A$ となるように配置する。かかる構成にて導体棒 4 S, 4 G 間に形成される高周波電界により効率良くプラズマが形成されることになる。よって高圧側の導体棒 4 S と接地側の導体棒 4 G とを交互に梯子状に並べることにより、電極全体として均一で大面積プラズマを生成することができる。

【0024】60MHz の高周波電力をこの梯子型電極 4 に給電した場合を想定し、二次元の数値シミュレーションを実施した結果、プラズマ中の電子密度の空間分布は図 3 のようになった。図 3 に示すように、電気密度は梯子型電極の導体棒の並びに沿って、連続的に分布しており、大面積で均一なプラズマ生成が可能であることを示している。すなわち、真空容器内に供給された反応ガスは、電極面に沿って生成されたプラズマによって分解され、反応種が生成される。この反応種は、通常この種のプロセスで用いられるガス圧である数 mTorr ~ 数百 mTorr のもとでは、速やかに拡散し加工物に達した付近では均一な分布となる。このため、この反応種による一様な加工が可能となる。

【0025】図 4 は図 1 の変形例を示したものであり、円筒状基板 5 1 に対して円筒状梯子型電極 4 1 を形成した例を示している。例えば、具体例として感光体ドラムに代表されるような円筒状の基板に対する CVD を前提としたものである。真空容器 1 内には円筒状梯子型電極 4 1 を円筒状基板 5 1 を保持する円筒状基板ホルダ 6 1 と同心に設置されている。この場合、円筒状梯子型電極 4 1 の梯子段を形成する導体棒の並びは図 4 の如く円周方向に並べても良いし、あるいは円筒軸方向に並べてもよい。

【0026】円筒状梯子型電極 4 1 には、図 1 の構成と同様マッチング回路 7 を介して高周波電源 8 が接続されており、更に高圧側導体棒と接地側導体棒との交互に配置により、円筒状梯子型電極 4 1 のこの導体棒に沿ってプラズマを生成できることは図 1 の場合と同様である。更に、図 1 と同様に円筒状梯子型電極 4 1 の背後にはシャワープレート 9 から反応性ガスが噴出するようにしてあり、プラズマによって分解された反応種により円筒状基板の表面に対する一様な成膜が可能となる。つまり、図 4 の構成では、図 1 のものを円筒状に形成した構成となっている。

【0027】図 5 は、更に他の例を示している。図 5 は基板 5 を載せるステージに第 2 の電極 1 1 を備え、この第 2 の電極 1 1 にマッチング回路 1 2 を介して別の高周波電源 1 3 を接続する構成を図 1 の構成に加えたものである。この図 5 によれば、第 2 の電極 1 1 上に載せた基板 5 の表面電位は高周波電力によってその周波数にて時間的に変動し、しかも真空容器 1 や基板ホルダ 6 が接地されて相対的に負電圧が重畳されることになるので、梯子型電極 4 により生成されたプラズマ中のイオンは、プラズマ中の空間電位と基板 5 の表面電位との間で時間的

に変動する電位差により加速され、成膜中の基板表面に入射する。

【0028】図 6 は第 2 の電極 1 1 に給電する高周波電力の周波数を変えた時の、基板 5 に入射する SiH_3 イオン（図中実線）と H^+ イオン（図中点線）の各々のイオンエネルギーの分布の変化を示したものである。図 6 に示すように低い周波数（例えば 13.56 MHz）ではエネルギー分布は広くなるが、周波数を高くすると（例えば 70 MHz）広がり小さくなることから、周波数の大きさによって入射イオンエネルギーを制御可能なことがわかる。高すぎるイオンエネルギーは膜中の欠陥密度を増大し膜質を劣化させる一方で、数十 eV 程度の入射エネルギーを持ったイオンは成膜中のアニーリング効果を助長し、膜質を緻密で良質なものにすることも知られているので、本例による高周波電力を用いたイオンエネルギーの制御は非常に有効である。

【0029】図 7 は、他の実施例であり、この図 7 では梯子型電極 4 と基板 5 との間にこの電極 4 や基板 5 を囲む大きさのリング状のガス管 1 4 を配置しており、このリング状のガス管 1 4 の内側には多数のガス噴出口が形状される構成を有している。このリング状のガス管 1 4 からは成膜前駆体のもとになる反応性ガスを流出するものであり、ガス導入系 2 からは成膜前駆体のもとになる反応性ガスとは別のガスを導入しそのガスが梯子型電極 4 の導体棒間に生成したプラズマによって分解してできた反応種により、ガス管 1 4 から導入した反応性ガスを分解して成膜を行なうようにしている。つまり、図 1, 図 4, 図 5 に示すように反応性ガスを直接プラズマにて分解することなく、別のガスの分解による反応種にてガス管 1 4 からの反応性ガスを分解することにより、成膜前駆体となる反応種の組成を制御することができる。

【0030】具体的には例えば、梯子型電極 4 背後のシャワープレート 9 からは Ar ガスを導入し、ガス管 1 4 からは SiH_4 ガスを導入すれば、プラズマ中の電子衝突によって生成した Ar 準安定原子と SiH_4 ガスの反応により SiH_3 を生成することから、成膜前駆体となる反応種 SiH_3 , SiH_2 等において SiH_2 の比率を上げることができる。また、例えば、シャワープレート 9 からは H_2 ガスを導入し、ガス管 1 4 からは同様に SiH_4 ガスを導入すれば、プラズマ中の電子衝突によって生成した H 原子と SiH_4 の反応により SiH_3 を生成することから、成膜前駆体となる反応種 SiH_3 , SiH_2 において SiH_3 の比率を上げることができる。いずれにしても、 SiH_4 ガスを直接プラズマによって分解し生成する反応種の組成とは異なる組成にすることができ、成膜反応の制御が可能となる。

【0031】以上図 1, 図 4, 図 5, 図 7 にて具体例を挙げたが、これらの具体例は相互適用が可能であり、例えば図 4 の円筒構造にて図 5, 図 7 の構成を組み合わせることができ、また、図 5 と図 7 の構成を組み合わせること

もできる。

【0032】こうして説明した如く、本例でのプラズマ CVD 装置では、高周波電力が給電される導体棒と接地された導体棒とを交互に梯子状に配列したことにより、少なくとも基板側は梯子状電極とは電氣的に独立したものとなり、電子密度分布が連続して均一な分布となり、成膜プロセスの自由度が増加し、高品質成膜のための制御性が向上し、一層の大面积薄膜が期待される。

【0033】これまでの説明においては、大面积で均一化したプラズマ生成につき述べたのであるが、ここで高周波電力についても言及する。高周波プラズマの生成は、基板へのイオンダメージを減少させる等高品質加工のため行なわれ、従来使用されてきた 13.56 MHz の外更に高い数十～数百 MHz の高周波電力が使用されつつある。ところが、高周波電力の高周波数化に伴い波長が電極サイズと同程度になると定在波が発生してしまい、プラズマ分布が不均一になったり、高周波による電子捕捉効果が強くなって電極と周囲の構造物との間に局所的にプラズマが生成されやすくなり、プラズマの大面积で均一な生成が困難になりつつある。

【0034】そこで、更なる改良として上記電子捕捉効果によりプラズマが局所化する性質を逆に利用して、プラズマ分布が不均一になるという問題を解決する。前述したように本発明の実施の形態の一例では、高周波電力が給電された導体棒 4 S と接地された導体棒 4 G を交互に梯子状に並べた複数の導体棒から成る梯子型電極 4 を真空容器 1 内に設置することにより、電極全体として大面积・均一なプラズマを生成し、一様な加工を実現するようにしたものであるが、高周波電力の周波数による波長 λ が梯子型電極 4 の寸法と比較して十分大きい場合には、この電極への給電については高压側金属棒 4 a への一点での給電点の設置で問題はない。ところが、高周波電力の周波数に基づく波長 λ により、 $\lambda/4$ の長さが電極の縦又は横の寸法と同程度になる場合には、定在波の発生によりプラズマの不均一を招来するため、高周波電源側からみて互いの距離が $\lambda/4$ 以下となる複数の給電点を設けることが考えられる。

【0035】図 8 を用いて、上述の梯子型電極 4 に給電する高周波電力の波長を λ とした時、電極の縦または横の寸法が $\lambda/4$ と同程度になる場合において、電極全体で電圧分布を一様にするための電極の構成について一例を説明する。この図 8 に示す例では、高压側金属棒 4 a と接地側金属棒 4 b とを一対ずつ設け、両側に接地側金属棒 4 b 1、4 b 2 を中央に高压側金属棒 4 a 1、4 a 2 をそれぞれ備えている。そして、高压側金属棒 4 a 1、4 a 2 にはそれぞれ 2 か所の給電点 16 a、16 b、16 c、16 d が設置され、電源からみた各給電点 16 a、16 b、16 c、16 d の距離を $\lambda/4$ 以下としている。

【0036】図 9 は、高周波電力の周波数と給電点間に

発生する電圧分布との関係を示している。100 MHz の場合、 $\lambda = 2 \text{ m}$ なので、給電点間距離 L と $L = \lambda/2$ の関係となり、この時非常に大きな電圧分布が発生する。 $L < \lambda/4$ となる 54.24 MHz 以下では、電圧分布はかなりの程度一様化されており、複数の給電点を設けた場合の互いの距離を $\lambda/4$ 以下とする根拠となっている。上記のように、複数の給電点を配置し、電極全体で導体棒に沿って電圧分布をほぼ一様に発生すれば、図 2 の場合と同様に各導体棒間において、一様なプラズマ生成が可能となり、高周波電力の周波数が高くなったために波長 λ が小さくなり、 $\lambda/4$ が電極寸法とほぼ同程度の場合でも、大面积で均一なプラズマの生成が可能となる。

【0037】上述の梯子型電極 4 に給電する高周波電力の周波数が高くなり、それを波長 λ とした時、 $\lambda/2$ が電極の縦または横の寸法より大きくなる場合、給電点の数も増やさなければならない。この時、電氣的に接続しており、かつ、電源から見て $\lambda/4$ 以上の離れた位置にある給電点が存在すると、これらの給電点により発生する定在波が互いに干渉して、結果的に電圧分布を悪化させる恐れがある。これを抑制し、電極全体で電圧分布を一様にするための電極の構成について図 10 を用いて説明する。図 10 は図 8 にて用いた複数給電された電極を一つの電極ユニット 17 として、必要な電極面積だけ複数のユニットを平面内に配置したもので、図は 4 ユニットの配置した例である。各ユニットには高周波電力が各々給電されているのみで、ユニット間は電氣的に接続されていない。こうすることによって、 $\lambda/4$ 以上離れた給電点同士の定在波の干渉はなくなり、各々均一にプラズマが生成されたユニットを平面内に配置することによって、全体として大面积で均一なプラズマの生成が可能となる。

【0038】

【発明の効果】以上説明したように本発明によれば、次の効果を奏する。第 1 の発明では、ガス導入系と排気系とが連通された真空容器内に、高周波電力供給手段に接続された電極とこの電極と対向して配置された基板とを有するプラズマ CVD 装置において、上記電極は、高周波電力が供給される導体棒と接地された導体棒とが相互に絶縁されて交互に梯子状に配列された梯子型電極としたことにより、基板側とは電氣的に独立することになり、プラズマ生成制御、イオン制御、均一化が図られ、成膜制御、膜質の劣化防止、更なる大面积化が図れる。

【0039】第 2 の発明は、第 1 の発明に加えて、上記電極を構成する高压側導体棒と接地側導体棒との間の距離 d は、高周波プラズマ中の電子の振幅 A の 2 倍に略等しいこととしたことにより、生成するプラズマを均一化する。

【0040】第 3 の発明では、第 1 又は第 2 の発明に加えて、上記電極は、円筒状梯子型電極とし、この電極の内側に円筒状基板を備えた円筒状基板ホルダを備えたこ

とにより、円筒形の基板に対処することができる。

【0041】第4の発明は、第1、第2又は第3の発明にあって、上記電極に接続される高周波電源とは別の高周波電源を基板を支持する第2の電極に接続することにより、第2電極により周波数の波長を変化させることで入射イオンエネルギーを制御でき、良質な膜質を得ることができる。

【0042】第5の発明は、第1、第2、第3又は第4の発明にあって、上記電極とこの電極と対峙する基板との間に反応性ガスを噴出する管を、上記梯子型電極及び基板のまわりに囲むように備えたことにより、ガス管からの反応性ガスをプラズマにて直接分解せず、別のガスを分解することで、反応種の組成制御が可能となる。

【0043】第6の発明は、第1、第2、第3第4又は第5の発明にあって、上記電極に給電する高周波電力の波長 λ としたとき、高周波電源からみた互いの給電点の距離が $\lambda/4$ 以下となる複数の給電点を備えたことにより、定在波発生によるプラズマ不均一を防止することができる。

【0044】第7の発明は、第1、第2、第3、第4又は第5の発明にあって、複数の給電点を備えた電極は、各給電点ごとに独立した電極に対応させてユニットを形成し、複数ユニットを形成したことにより、大面積で均一なプラズマ生成とすることができる。

【0045】第8の発明は、上記各発明にあって、基板上にプラズマにて成膜した電子デバイスを製造するものである。

【図面の簡単な説明】

【図1】本発明の実施の形態の一例の断面図。

【図2】電極を主に示した簡略斜視図。

【図3】図1におけるシミュレーション結果の電子密度分布図。

【図4】円筒型の変形例を示す断面図。

【図5】別の高周波電源を有する例の断面図。

【図6】周波数をパラメータとしたイオンエネルギー状態図。

【図7】反応性ガスのガス管を備えた例の断面図。

【図8】複数給電点を有する例の斜視図。

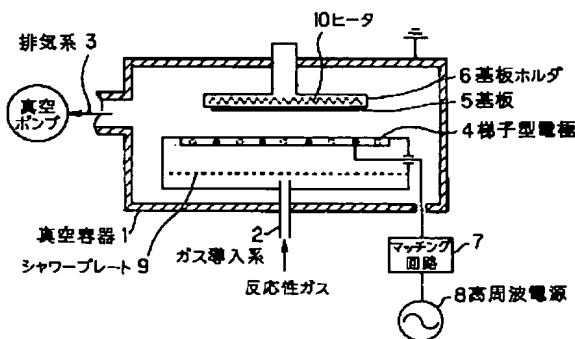
【図9】給電点間距離に対する電圧分布図。

【図10】電極ユニット構成の簡略斜視図。

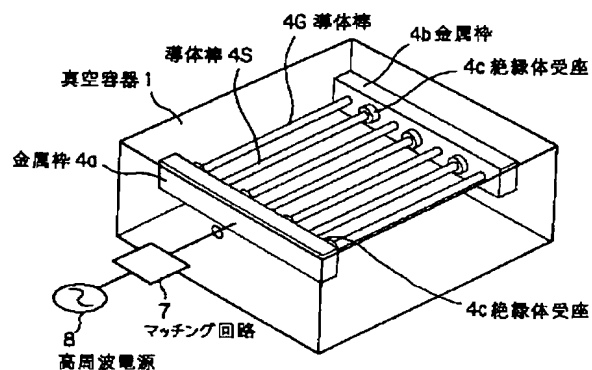
【符号の説明】

- 1 真空容器
- 4 梯子型電極
- 4a, 4b, 4a1, 4b1, 4a2, 4b2 金属棒
- 4S, 4G 導体棒
- 4c 絶縁体受座
- 5 基板
- 6 基板ホルダ
- 8, 13 高周波電源
- 11 第2の電極
- 14 ガス管
- 16a, 16b, 16c, 16d 給電点
- 17 電極ユニット

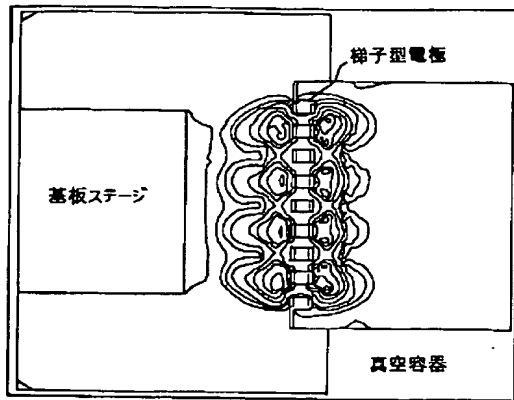
【図1】



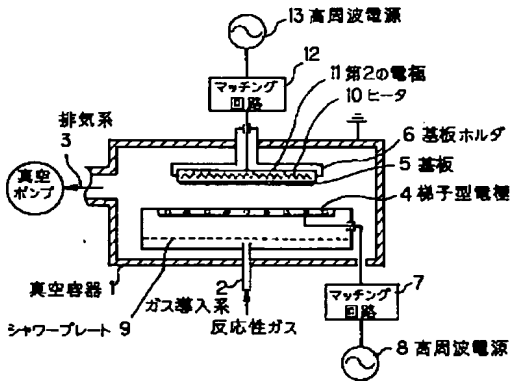
【図2】



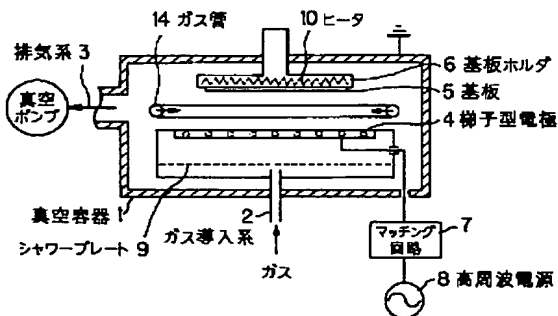
【図 3】



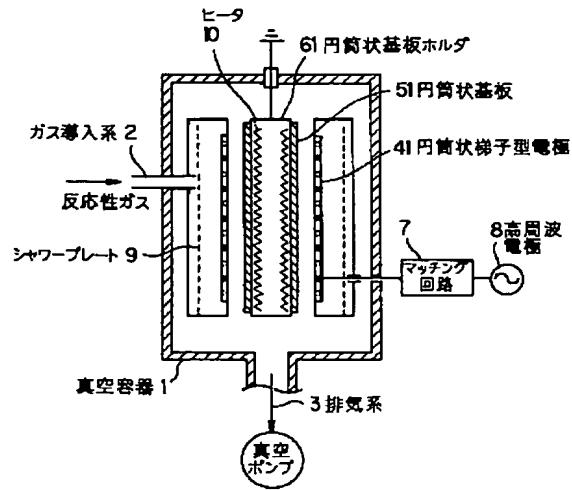
【図 5】



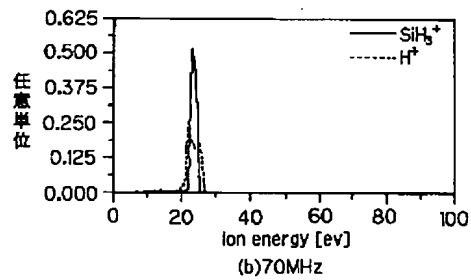
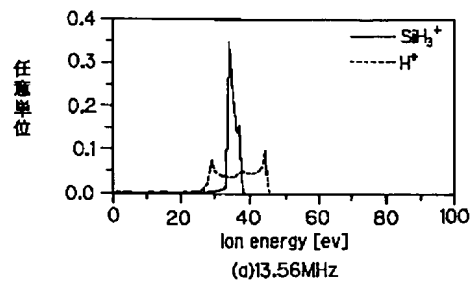
【図 7】



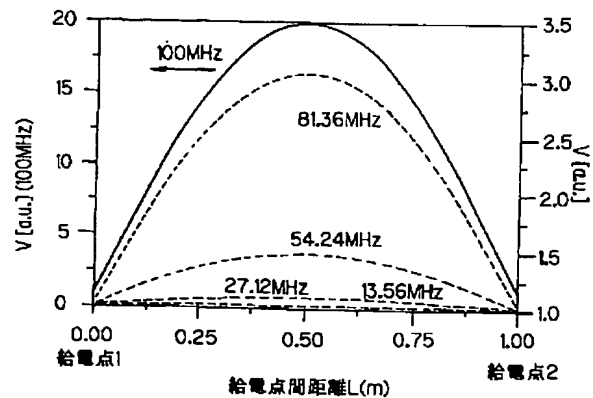
【図 4】



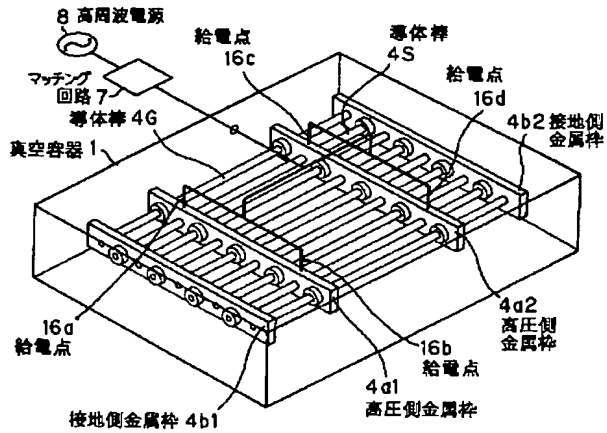
【図 6】



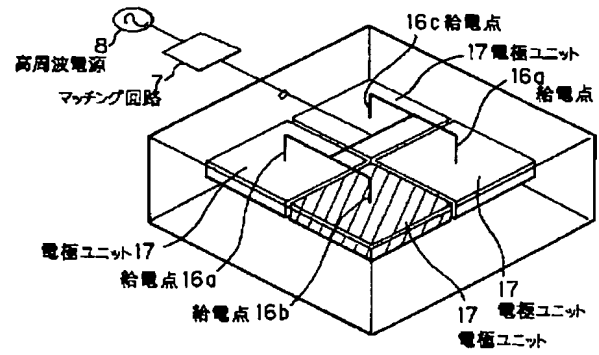
【図 9】



【図 8】



【図 10】



フロントページの続き

(72) 発明者 山越 英男
神奈川県横浜市金沢区幸浦一丁目 8 番地 1
三菱重工業株式会社基盤技術研究所内

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